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institute	: TNO Physics and Electronics Laboratory
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Research supervised by	: Ir. J.G. van Hezewijk
Research carried out by	: Ir. H.J. Visser

ABSTRACT (UNCLASSIFIED)

First near-field tests in using low-PRF pulsed signals with a standard (CW) HP 8510B Vector Network Analyzer are performed. Although the measurement system did have a loss of 50 dB, it was possible to obtain radiation patterns down to 40 dB below the maximum. The tests have proven that it is possible to obtain accurate antenna characteristics under pulsed conditions for low PRF's spending only a few milliseconds per near-field grid point in the FEL-TNO planar near-field measurement facility.

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SAMENVATTING (ONGERUBRICEERD)

De eerste nabije-veld testen in het gebruik van lage PRF gepulste signalen met een standaard (CW) HP 8510B Vector Network Analyzer zijn uitgevoerd. Hoewel het meetsysteem een verlies had van 50 dB, was het mogelijk antennepatronen te verkrijgen tot 40 dB onder het maximum. De testen hebben aangetoond dat het mogelijk is nauwkeurige antenne karakteristieken te verkrijgen onder gepulste condities, waarbij slechts een paar milliseconden per nabije-veld grid punt worden gespendeerd, in de FEL-TNO planaire nabije-veld meetfaciliteit.

1 INTRODUCTION

Now, that the fundamentals of measuring low-PRF pulsed signals with a standard (CW) HP 8510B NWA within milliseconds have been shown [1], the time has arrived that pulsed measurement tests in the FEL-TNO planar near-field measurement facility have to be performed. CW measurements as well as pulsed measurements with the HP 8510B are performed on a transmitting Antenna Under Test (AUT). The AUT is a 1 m diameter C-band parabolic antenna with a Geyerhorn as feedhorn. F/D = 0.4. Pulsed measurement results will be compared with CW measurement results.

2 MEASUREMENT CONFIGURATIONS

The near-field low-PRF pulsed measurement configuration [1, p.30] is shown in figure 1.

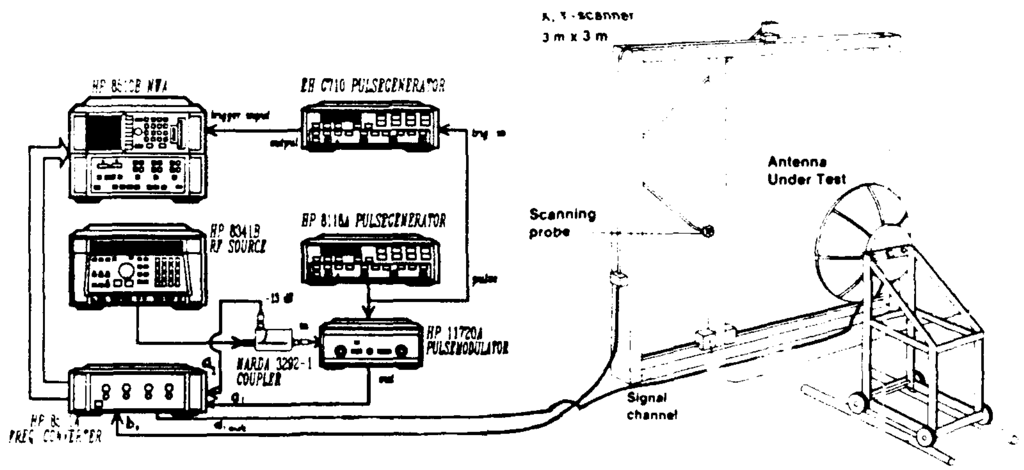

Fig. 1: Low-PRF pulsed measurement configuration

The AUT is operated with a carrier frequency of 5.3 GHz and a Pulse Repetition Frequency of 3.5 kHz with a pulsewidth of 12.8 μs.

In the CW measurement configuration, the external trigger connection with the NWA is removed; use will be made of internal triggering. Both pulsegenerators are turned off, but the pulsemodulator will remain, though inactive, in order to maintain the same RF-path as used with pulsed measurements.

3 MEASUREMENT RESULTS

Before the near-field measurement results are discussed, some remarks about the near-field measurement system loss have to be made.

Measurements of amplitude and phase are carried out both CW and pulsed, with the probe positioned in front of the AUT and with the probe positioned in the upper left corner of the scan frame (see figure 1). The measurement results are stated in table 1.

Table 1: Amplitude and phase vs probe position

Probe position	Amplitude CW (dB)	Phase CW (°)	Amplitude Pulsed (dB)	Phase Pulsed (°)
In front of AUT	-27.91 ± 0.15	-164.60 ± 0.90	-27.80 ± 0.20	-165.25 ± 1.10
In upper left corner of frame	-63.77 ± 6.0	-25.16 ±80	-64.61 ± 8.0	-23.57 ±90

CW : source power = 9 dBm

Pulsed: source power = 20 dBm

The fluctuations in the measured values, especially those measured at the edge of the scan frame, indicate - considering the measurement results as stated in [1] - a considerable loss in the near-field measurement system.

When a_{1out} is directly connected to b_1 (see figure 1), a CW amplitude measurement gives: 23.0 ± 0.010 dB. So, with table 1, it appears that the near-field measurement system loss is about 50 dB (at the centre of the scan plane).

With this cause of large fluctuations away from the centre of the scan plane in mind, we can now look at differences in near-field data and in calculated far-field data.

Figure 2 shows the near-field amplitude, measured in the CW measurement configuration 1). Figure 3 shows the amplitude, measured in the pulsed-RF measurement configuration. The colours indicate lines of equal amplitude. Above and at the right of the figures, the amplitude patterns through the centres of the scan plane are indicated.

1) Near-field measurement software developed at FEL-TNO.

Figure 4 shows the difference of the data of figure 2 and 3. This difference is negligible at the centre of the scan plane and increases going toward the edges of the scan plane, the reason of which is already mentioned before. Above and at the right of figure 4, the amplitude difference patterns through the centres of the scan plane are shown.

Figure 5, 6 and 7 respectively show near-field phase measured in the CW measurement configuration, phase measured in the pulsed-RF measurement configuration and the phase difference. Above and at the right of these figures phase patterns, respectively phase difference patterns through the centres of the scan plane are shown.
The remarks made for the amplitude patterns also apply for the phase patterns.

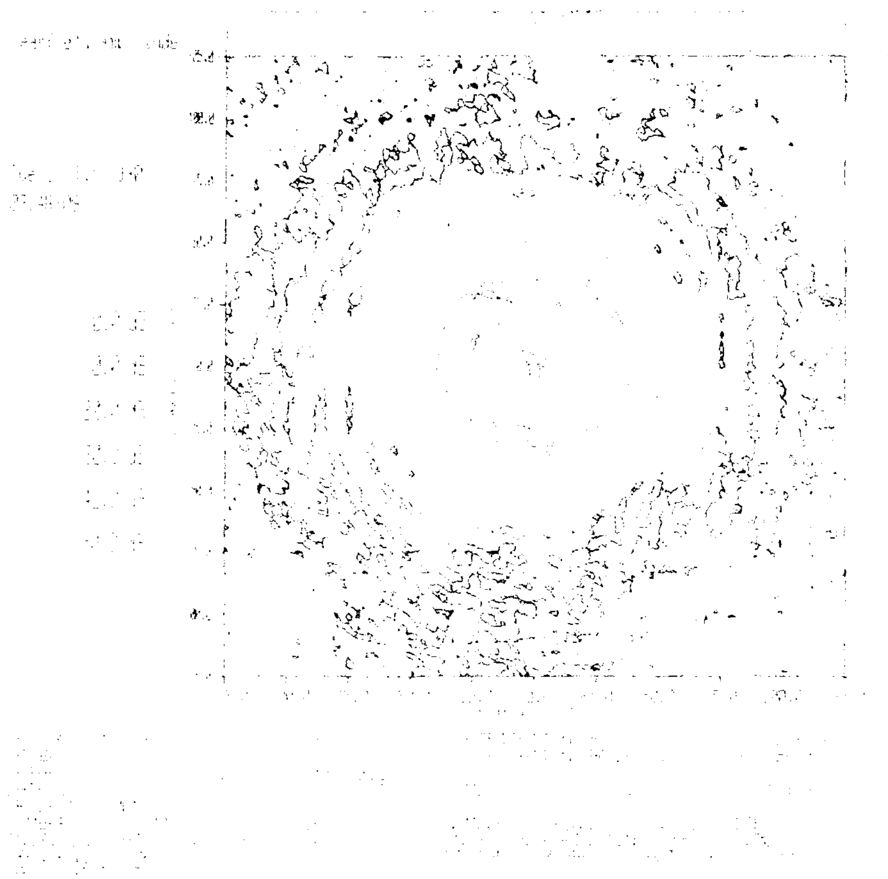

Fig. 2: Near-field amplitude, CW measurement

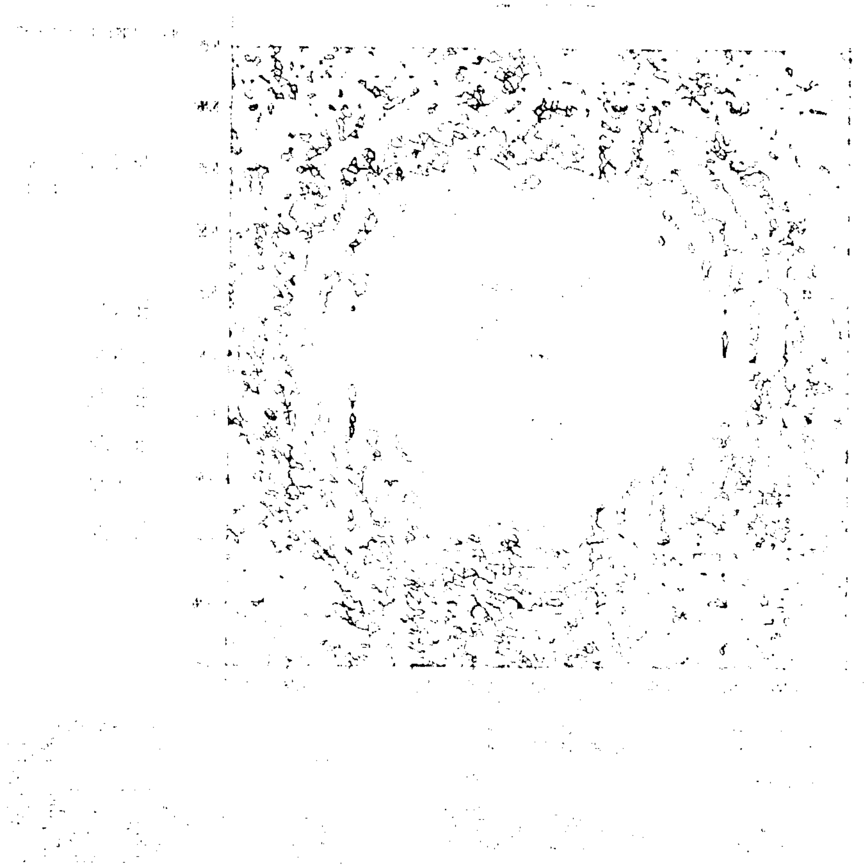

Fig. 3: Near-field amplitude, Pulsed-RF measurement

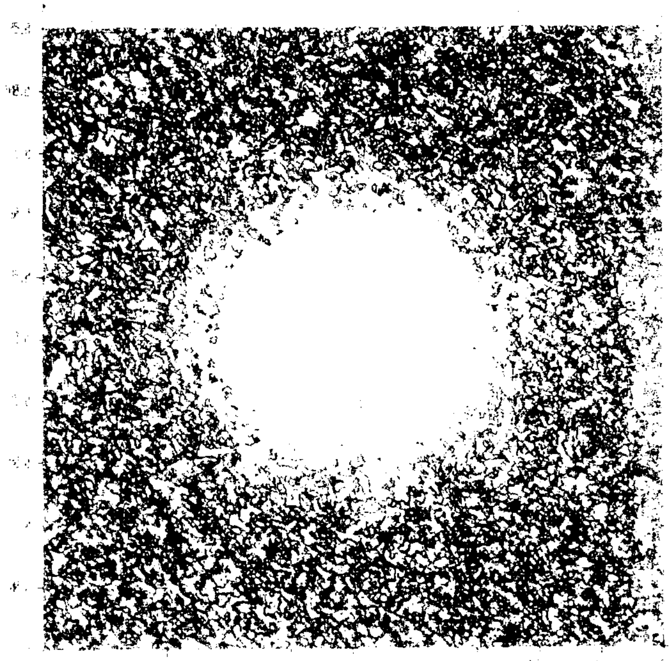

Fig. 4 Near field amplitude difference: CW measurement - Pulsed-RF measurement

Differences in amplitude and phase are calculated by taking the absolute values of the data of two datafiles, normalizing the data to the maximum value of the first datafile, subtracting the data and taking 10 times the logarithm to get the difference in dB's.

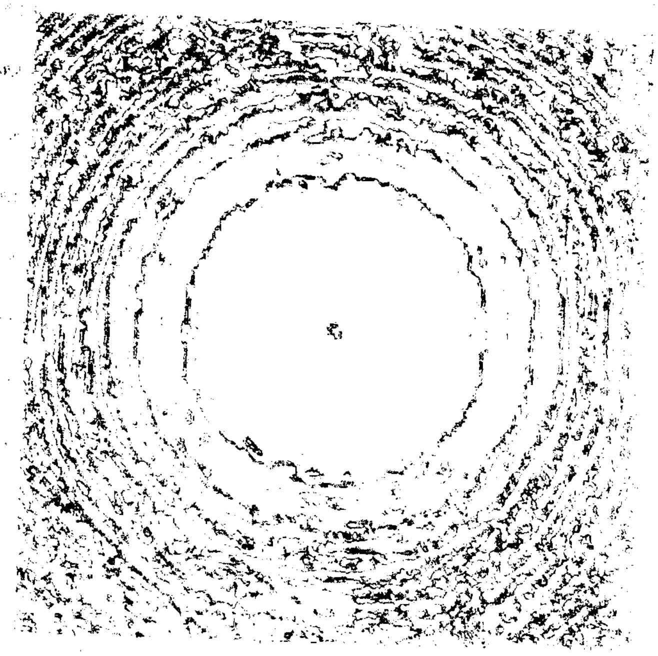

Fig. 5 Near field phase, CW measurement

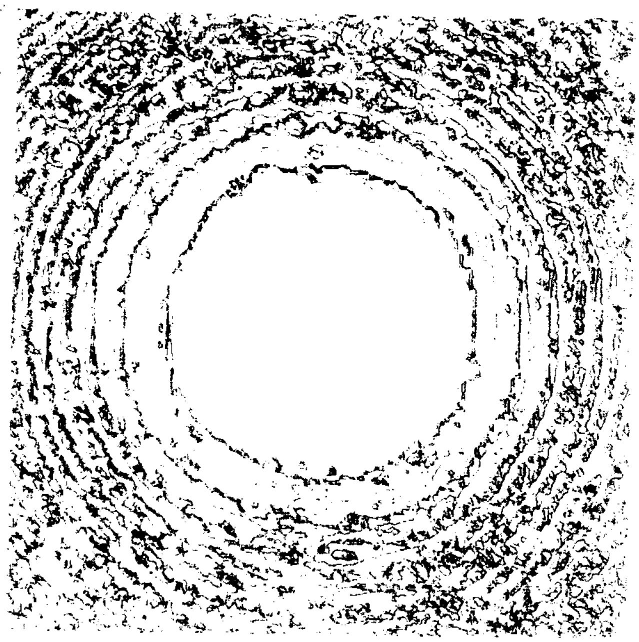

Fig. 6 Near-field phase. Pulsed RF measurement

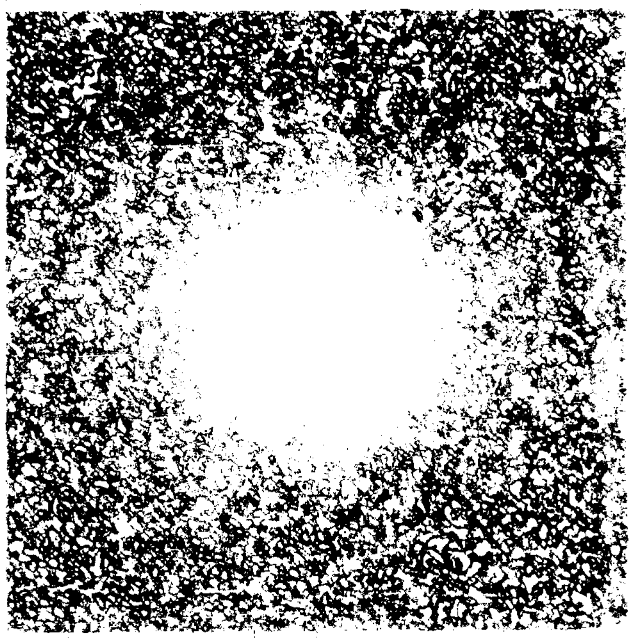

Fig. 7. Near-field phase difference: CW measurement - Pulsed-RF measurement

In order to show that the differences between CW and pulsed measurements are mainly due to the noticed fluctuations, one column of the scan plane is measured three times (in the CW measurement configuration). Subtracted amplitude and phase show values corresponding with the fluctuations as stated in table 1. Figure 8 shows the subtracted amplitudes of two column-measurements, figure 9 shows the subtracted phase of two column-measurements.

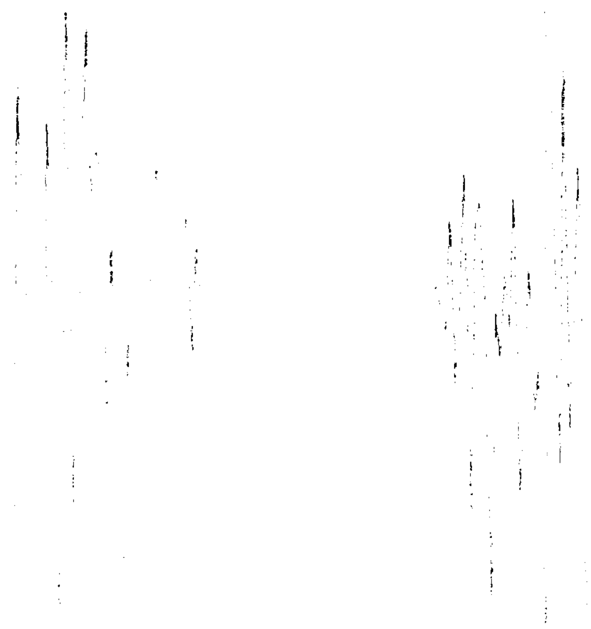

Fig. 8 Near field amplitude difference: one column CW measurement configuration

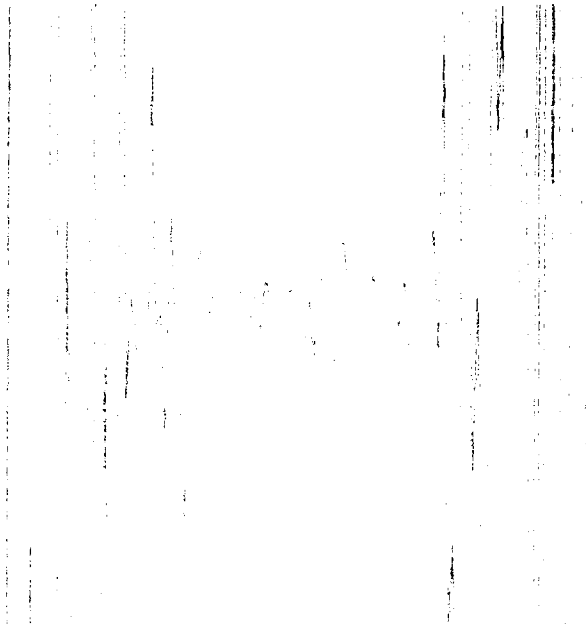

Fig. 9 Near-field phase difference, one column CW measurement configuration

With the near-field data as shown in the foregoing, far-fields are calculated. Figure 10 gives a 3-dimensional impression of the far-field amplitude, calculated from the near-field data measured in the CW measurement configuration. Figure 11 gives the contour plot of the far-field amplitude obtained from the CW near-field measurement; figure 12 gives the contour plot of the far-field phase.

Figure 13 gives the contour plot of the far-field amplitude obtained from the pulsed-RF near-field measurement; figure 14 gives the contour plot of the far-field phase.

Fig 10.   Far-field amplitude: calculated from CW measurement

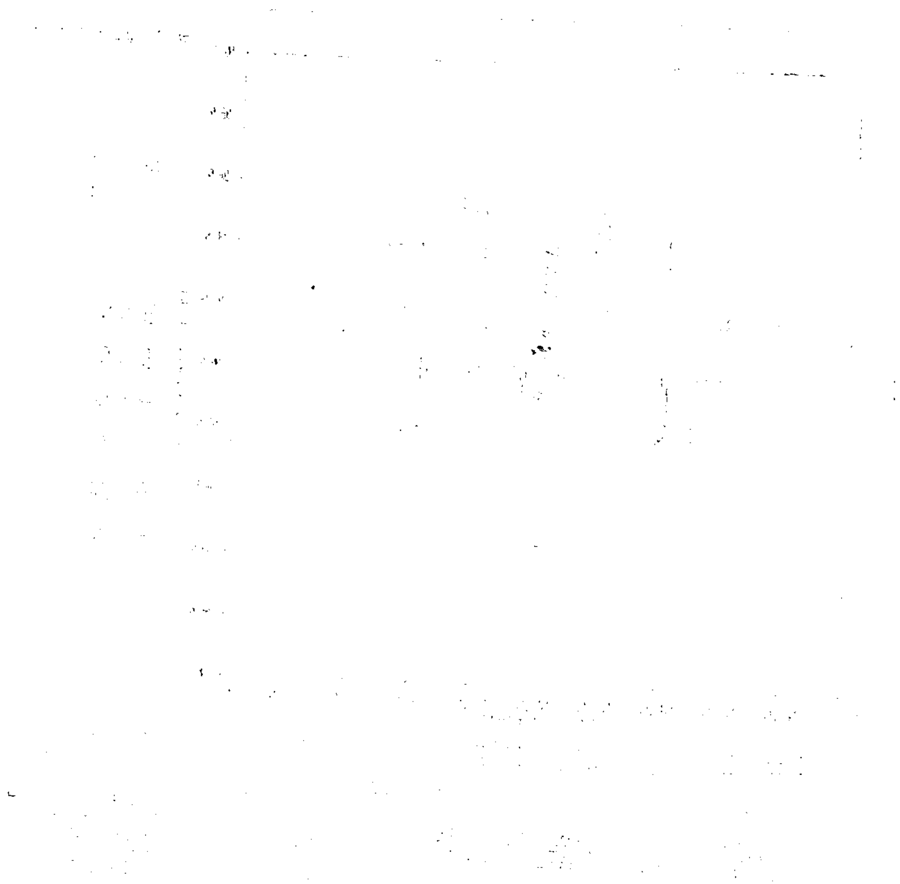

Fig. 11 Far-field amplitude, calculated from CW measurement

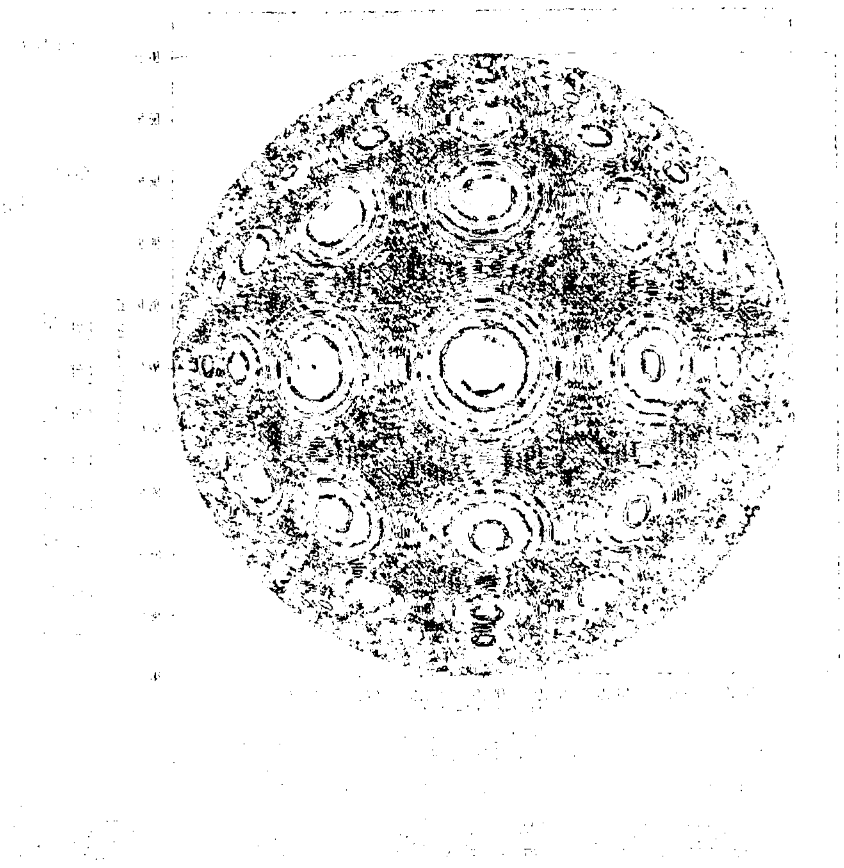

Fig 12   Far field phase: calculated from CW measurement

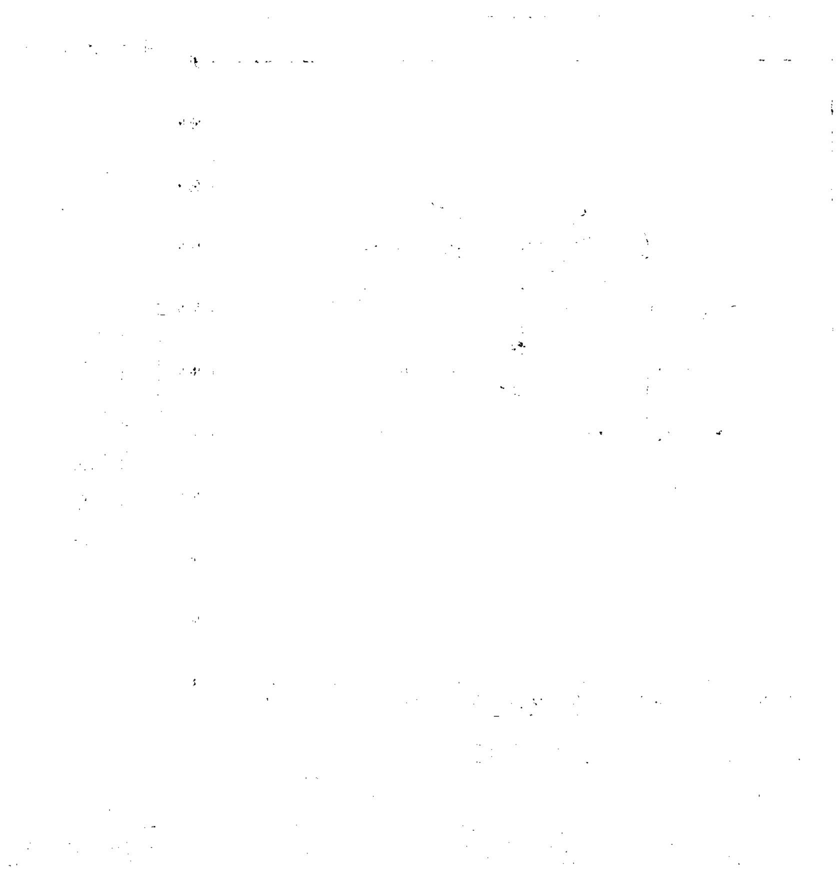

Fig. 13. Far-field amplitude; calculated from pulsed-RF measurement

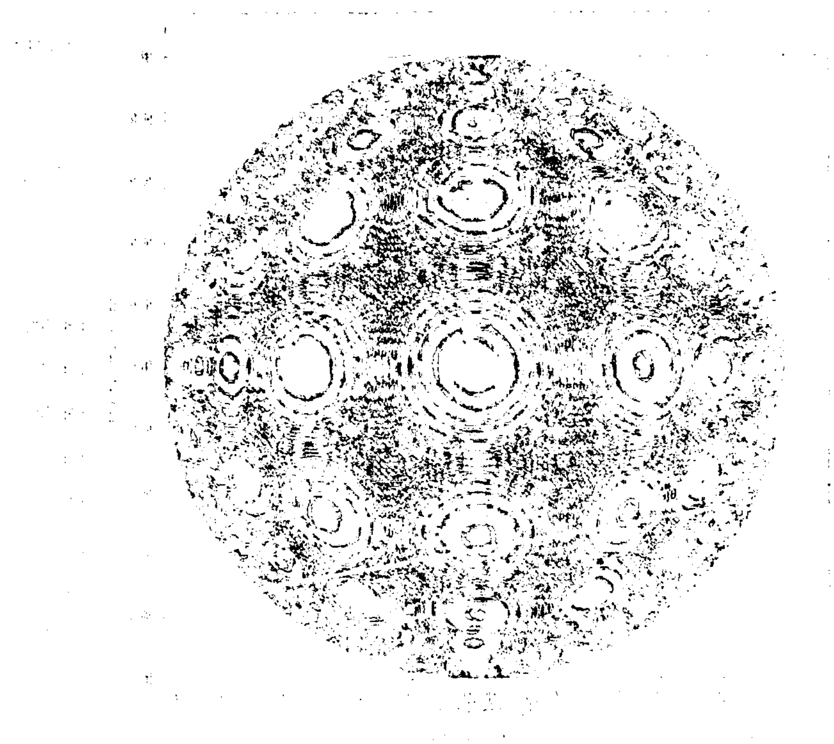

Fig. 14: Far-field phase; calculated from pulsed-RF measurement

In figure 15 and 16, far-field amplitude and phase differences are shown. Since the plot program is not meant for plotting this information, the axes do not agree with the figure. The figures are shown anyhow, since they give a good impression of the differences in the far-field.

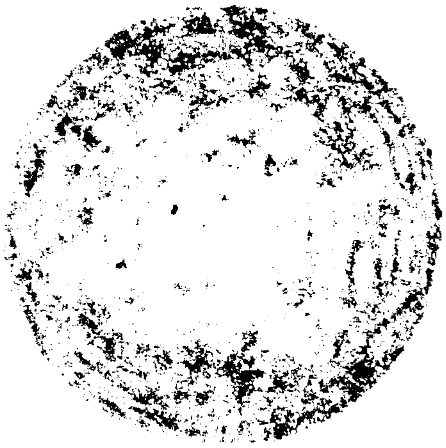

Fig 15: Far-field amplitude difference: CW measurement values - Pulsed-RF measurement values

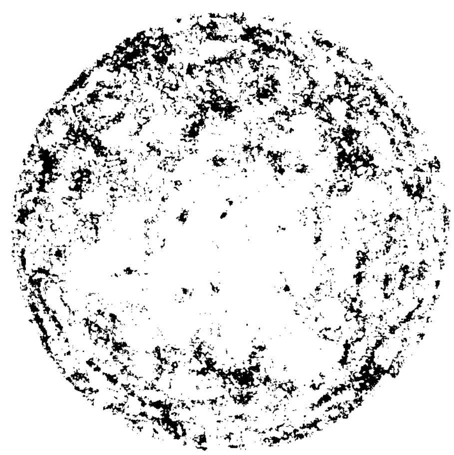

Fig. 16: Far-field phase difference; CW measurement values - Pulsed-RF measurement values

An even better impression of the amplitude differences can be obtained by showing the radiation patterns in the principal planes. This is done in figure 17 and 18. The blue pattern is obtained from the CW measurement configuration; the green one from the pulsed-RF measurement configuration. The horizontal axes do not agree with the figure.

Fig. 17 Principal plane radiation patterns

The above figure is the vertical cross section of figure 10. The figure on the following page (figure 18) is the horizontal cross section of figure 10.

Fig. 18 Principal plane radiation patterns

The radiation patterns agree very well. It appears that the near-field measurement fluctuations cancel out when calculating the far-field, due to the integration of the near-field data [2].
As a last check, the far field obtained with the pulsed-RF measurement configuration is compared with the far-field obtained with a totally different CW measurement system as is in use for a couple of years in the FEL-TNO planar near-field measurement facility. This measurement system is build up around a Scientific Atlanta receiver series 1780 (see appendix A for the measurement configuration). Figure 19 and 20 give the principle plane radiation patterns. The radiation pattern obtained with the SA receiver is given in blue, the one obtained with the HP pulsed-RF measurement system is given in green.

Fig. 19: Principle plane radiation patterns

The above figure is the vertical cross section of figure 10. The figure on the following page (figure 20) is the horizontal cross section of figure 10.

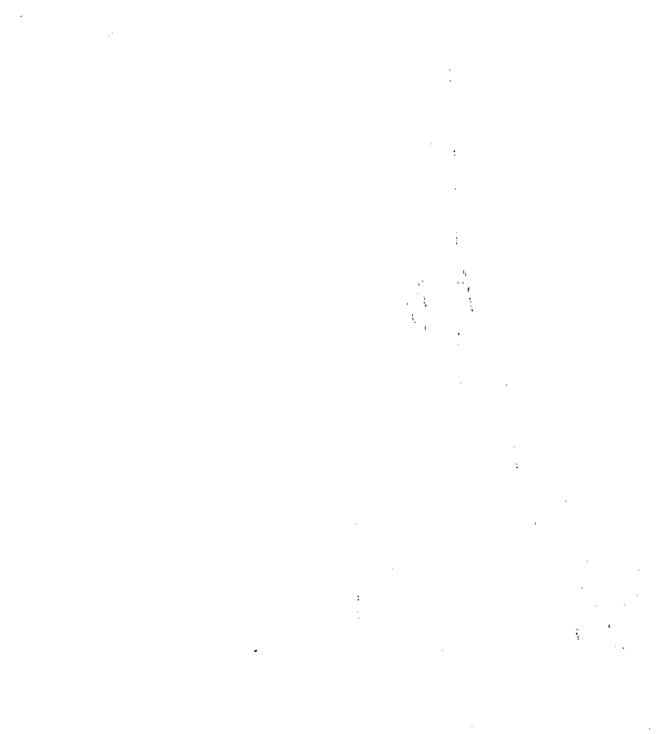

Fig. 20 Principle plane radiation patterns

In the above figures we see a very good agreement between the radiation patterns, what proves that the pulsed-RF measurement method as described in [1] is suitable for near-field measurement.

4 CONCLUSIONS

First pulsed-RF near-field measurements carried out with a standard (CW) HP 8510B vector network analyzer have shown that it is possible to obtain accurately antenna characteristics under pulsed conditions for low PRF's and within milliseconds.

Measurements were carried out for a carrier frequency of 5.3 GHz and a Pulse Repetition Frequency of 3.5 kHz with a pulsewidth of 12.8 μs.

Although the measurement system did have a loss of 50 dB, accurate antenna patterns down to 40 dB below the maximum were obtained. When the loss is minimized or when the transmitting AUT source power is increased, the accuracy is expected to increase.

5 REFERENCES

[1] Visser, H.J.: *"Measuring low-PRF pulsed signals with a standard HP 8510B vector network analyzer within milliseconds"*,
Physics & Electronics Laboratory TNO, Report FEL-90-B238, July 1990.

[2] Visser, H.J.: *"Theory of planar near-field measurement"*,
Physics & Electronics Laboratory TNO, Report FEL-89-B273, December 1998.

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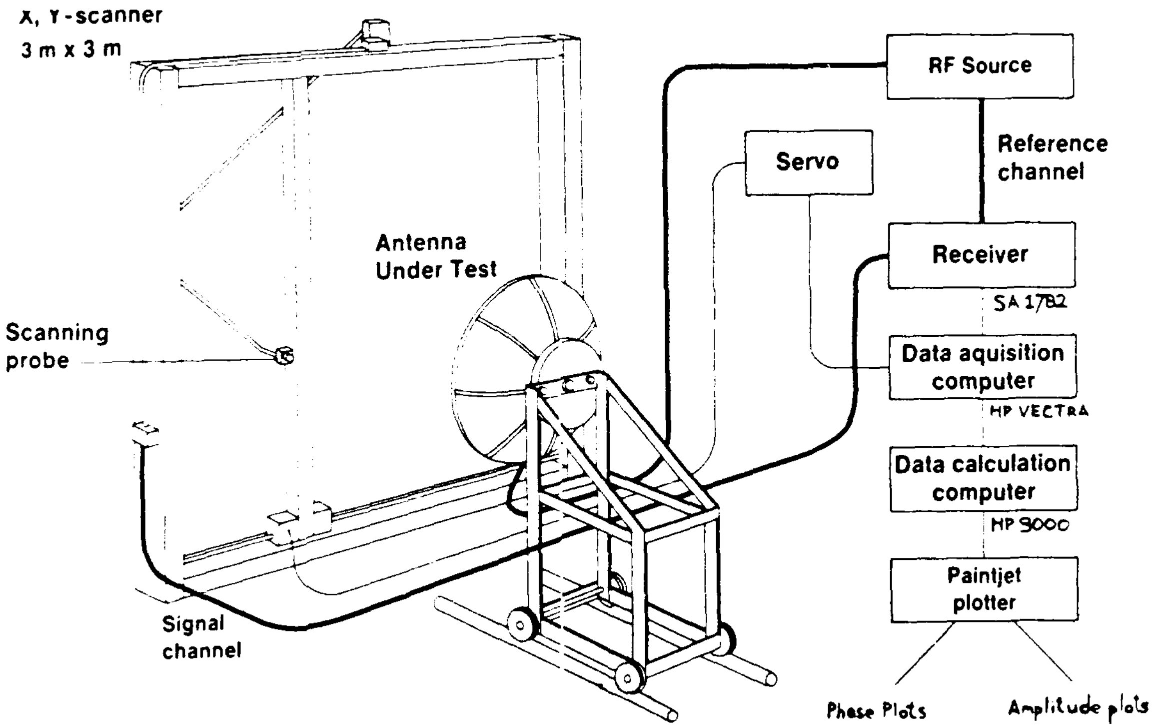
APPENDIX A: FEL-TNO PLANAR NEAR-FIELD MEASUREMENT SYSTEM



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15. ABSTRACT (MAXIMUM 200 WORDS, 1044 POSITIONS)

FIRST NEAR-FIELD TESTS IN USING LOW-PRF PULSED SIGNALS WITH A STANDARD (CW) HP 8510B VECTOR NETWORK ANALYZER ARE PERFORMED. ALTHOUGH THE MEASUREMENT SYSTEM DID HAVE A LOSS OF 50 DB, IT WAS POSSIBLE TO OBTAIN RADIATION PATTERNS DOWNTO 40 DB BELOW THE MAXIMUM. THE TESTS HAVE PROVEN THAT IT IS POSSIBLE TO OBTAIN ACCURATE ANTENNA CHARACTERISTICS UNDER PULSED CONDITIONS FOR LOW PRF'S SPENDING ONLY A FEW MILLISECONDS PER NEAR-FIELD GRID POINT IN THE FEL-TNO PLANAR NEAR-FIELD MEASUREMENT FACILITY.

16. DESCRIPTORS	IDENTIFIERS
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SHORT DURATION PULSES	NEAR FIELD MEASUREMENT
ANTENNA RADIATION PATTERNS	

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